Technical Fact Sheet – Dinitrotoluene (DNT)

February 2017

United States Environmental Protection Agency

TECHNICAL FACT SHEET – DNT

At a Glance

- Nitroaromatic explosive that exists as six isomers: 2,4- and 2,6-DNT are the most common forms.
- Not naturally found in the environment.
- Used as an intermediate in the production of ammunition, polyurethane polymers, dyes, plasticizers and automobile airbags.
- Found in waste streams of DNT manufacturing or processing facilities.
- Expected to remain in water for long periods of time because of its relatively low volatility and moderate water solubility.
- Adverse effects identified in the blood, nervous system, liver and kidney in animals after exposure.
- Classified as a Class B2 (probable human) carcinogen.
- Health-based goals, exposure limits, screening levels and state drinking water guidelines have been developed.
- Standard detection methods include gas chromatography (GC) and high-performance liquid chromatography (HPLC).
- Common treatment technologies include adsorption, chlorination, ozonation, ultraviolet radiation, alkaline hydrolysis and bioremediation.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a summary of dinitrotoluene (DNT), including physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers and field personnel who may address DNT contamination at cleanup sites or in drinking water supplies.

The widespread use of DNT in manufacturing munitions, polyurethane foams, and other chemical products has contributed to extensive soil and groundwater contamination. DNT can be transported in surface water or groundwater because of its moderate solubility and relatively low volatility, unless degraded by light, oxygen or biota. As a result, releases to water are important sources of human exposure and remain a significant environmental concern. DNT is considered toxic to most organisms, and chronic exposure may result in organ damage. EPA currently classifies DNT as a priority pollutant.

What is DNT?

- DNT is a nitroaromatic explosive that exists as six isomers: 2,4- and 2,6-DNT are the two major forms; 2,3-DNT, 2,5-DNT, 3,4-DNT and 3,5-DNT are minor isomers (ATSDR 2016; Lent and others 2012a).
- Technical grade DNT (Tg-DNT) is about 76.5% 2,4-DNT, 18.8% 2,6-DNT, and 4.7% minor isomers (2.43% 3,4-DNT, 1.54% 2,3-DNT, 0.69% 2,5-DNT, and 0.04% 3,5-DNT (ATSDR 2016; Lent and others 2012a).
- DNT is not found naturally in the environment. It is usually produced by mixing toluene with nitric and sulfuric acids and is an intermediate in 2,4,6-trinitrotoluene (TNT) manufacturing (ATSDR 2016; EPA 2008).
- A mixture of DNTs is sold as an explosive and is a starting material for the production of 2,4,6-TNT. The mixture is also used as a modifier for smokeless powders in the munitions industry, in airbags of automobiles, as a chemical intermediate for the production of toluene diisocyanate (TDI), dyes and urethane foams (ATSDR 2016; EPA 2008).
- There are currently a small number of DNT manufacturing facilities in the United States (EPA 2008).

Exhibit 1: Physical and Chemical Properties of 2,4- and 2,6-DNT
(ATSDR 2016; EPA 2008)

Property		
Chemical Abstracts Service (CAS) number	121-14-2	606-20-2
Physical description (physical state at room temperature and atmospheric pressure)	Yellow solid	Yellow to red solid
Molecular weight (g/mol)	182.14	182.14
Water solubility (mg/L)	270 at 22 °C	180 at 20 °C
Melting point (°C)	71	66
Boiling point (°C)	300	285
Vapor pressure at 20 °C (mm Hg)	1.4×10^{-4}	5.67×10^{-4}
Specific gravity/Density	1.32 at 71 °C	1.28 at 111 °C
Octanol-water partition coefficient (log K_{ow})	1.98	2.10
Organic-carbon partition coefficient (log K_{oc})	1.65	1.96
Henry's law constant (atm-m^3/mol)	5.4×10^{-8}	7.47×10^{-7}

Abbreviations: g/mol – grams per mole; mg/L – milligrams per liter; °C – degree Celsius; mm Hg – millimeters of mercury; atm-m^3/mol – atmosphere-cubic meters per mole.

What are the environmental impacts of DNT?

- DNT is commonly found in surface water, groundwater and soil at hazardous waste sites that contain buried ammunitions waste or waste from facilities that manufacture or process DNT (EPA 2008; Darko-Kagya and others 2010; Lent and others 2012a).
- As of 2016, DNT has been identified at 56 sites on the EPA National Priorities List (NPL) (EPA 2016a).
- Because of their low vapor pressures and low Henry's Law constants, 2,4- and 2,6-DNT do not usually volatize from water or soil. The isomers are usually released to air in the form of dusts or aerosols from manufacturing plants or adsorbed to other suspended particles (EPA 2008).
- 2,4- and 2,6-DNT have only a slight tendency to sorb to sediments, suspended solids or biota based on their relatively low organic-carbon partition coefficients (EPA 2008).
- The retention of DNT in soil depends on the chemistry and content of the soil organic matter (Clausen and others 2011; Singh and others 2010).
- Unless broken down by light, oxygen or biota, DNT is expected to remain in water for long periods of time because of its relatively low volatility and moderate water solubility. As a result, DNT has the potential to be transported by groundwater or surface water (ATSDR 2016; EPA 2008).
- Vapor-phase 2,4- and 2,6-DNT have an estimated half-life of 75 days in the atmosphere and are broken down by photodegradation (EPA 2008; HSDB 2013).
- Photolysis is the primary means for DNT degradation in oxygenated water. The photodegradation of 2,6-DNT was assessed under simulated solar radiation in a seawater solution. Within 24 hours, 2,6-DNT had been reduced by 89 percent and after 72 hours had been fully degraded (EPA 2008; NAVFAC 2003).
- Biodegradation of 2,4- and 2,6-DNT in water can occur under both aerobic and anaerobic conditions (EPA 2008).
- Microorganisms indigenous to surface soil and aquifer materials collected at a munitions-contaminated site were able to transform 2,4- and 2,6-DNT to amino-nitro intermediates within 70 days (Bradley and others 1994).
- 2,4- and 2,6-DNT have relatively low octanol-water partition coefficients and, as a result, are not expected to bioaccumulate significantly in animal tissue (ATSDR 2016).
- As a result of its moderate solubility, DNT can be transferred to plants via root uptake from soil and is expected to accumulate readily in plant materials (EPA 2008).
- DNT's bioavailability and toxicity to plants are greatly altered by soil properties. Studies have found that the toxicity of 2,4- and 2,6-DNT for various plant species is significantly and inversely correlated with soil organic matter content (Rocheleau and others 2010).

What are the routes of exposure and the health effects of DNT?

- Potential exposure pathways include inhalation, dermal contact and incidental ingestion, usually in occupational settings (ATSDR 2016; EPA 2008).
- Adverse health effects posed by chronic DNT exposure have been identified in the central nervous system, heart and circulatory system of humans. Exposure to 2,4- and 2,6-DNT can lead to increased incidences of mortality from ischemic heart disease, hepatobiliary cancer, and urothelial and renal cell cancers (EPA 2008).
- Identified symptoms from prolonged exposure to DNT include nausea, headache, methemoglobinemia, jaundice, anemia and cyanosis (EPA 2008; Darko-Kagya and others 2010; OSHA 2013).
- 2,4- and 2,6-DNT have both shown adverse impacts to neurological, hematological, reproductive, hepatic and renal functions in animal studies of rats, mice and dogs (EPA 2008).
- Both isomers are moderately to highly toxic to rats and mice (EPA 2008; Hartley and others 1994).
- Symptoms such as cyanosis, anemia, increased splenic mass and hepatocellular lesions were observed in rats exposed to 2,4- and 2,6-DNT for 14 days (Lent and others 2012b).
- Animal studies have also shown that both 2,6- and Tg-DNT are hepatocarcinogens and can cause liver cancer in rats. Studies indicate that the hepatocarcinogenity of Tg-DNT could be attributed to the 2,6-DNT isomer (Lent and others 2012a).
- EPA classified the mixture of 2,4- and 2,6-DNT as a Class B2 (probable human) carcinogen based on multiple benign and malignant tumor types at multiple sites in rats and malignant renal tumors in male mice (EPA IRIS 1990).
- The American Conference of Governmental Industrial Hygienists (ACGIH) has classified DNT as a Group A3 carcinogen – confirmed animal carcinogen with unknown relevance to humans (HSDB 2013).

Are there any federal and state guidelines and health standards for DNT?

- EPA's Integrated Risk Information System (IRIS) database includes a chronic oral reference dose (RfD) of 2 x 10^{-3} milligrams per kilogram per day (mg/kg/day) for 2,4-DNT based on neurotoxicity and the presence of Heinz bodies and biliary tract hyperplasia in animals (EPA IRIS 1992).
- Based on a provisional peer-reviewed toxicity value (PPRTV) assessment conducted by the EPA for both 2,6-DNT and Tg-DNT, EPA established a provisional chronic RfD screening value of 3 x 10^{-4} mg/kg/day for 2,6-DNT and 9 x 10^{-4} mg/kg/day for Tg-DNT. The PPRTV assessments are developed for use in the EPA Superfund program and provide toxicity values and information about adverse effects of the chemical (EPA 2013a, b).
- The Agency for Toxic Substances and Disease Registry (ATSDR) has established a minimal risk level (MRL) of 0.05 mg/kg/day for acute-duration oral exposure (14 days or less), 0.007 mg/kg/day for intermediate-duration oral exposure (15 to 364 days) and 0.001 mg/kg/day for chronic-duration oral exposure (365 days or more) to 2,4-DNT (ATSDR 2013, 2016).
- For 2,6-DNT, an MRL of 0.09 mg/kg/day has been derived for acute-duration oral exposure and 0.004 mg/kg/day was derived for intermediate-duration oral exposure (ATSDR 2013, 2016).
- The cancer risk assessment for the 2,4- and 2,6-DNT mixture is based on an oral slope factor of 6.8 x 10^{-1} mg/kg/day and a drinking water unit risk of 1.90 x 10^{-5} micrograms per liter (µg/L) (EPA 2008; EPA IRIS 1990).
- EPA risk assessments indicate that the drinking water concentration representing a 1 x 10^{-6} cancer risk level for 2,4- and 2,6-DNT mixture is 0.05 µg/L (EPA IRIS 1990).
- The EPA has established drinking water health advisories for DNT, which are drinking water-specific risk level concentrations for cancer (10^{-4} cancer risk) and concentrations of drinking water contaminants at which noncancer adverse health effects are not anticipated to occur over specific exposure durations (EPA 2012a).
  - EPA established a 1-day and 10-day health advisory of 1.0 mg/L for 2,4-DNT in drinking water for a 10-kilogram (kg) child.
  - For 2,6-DNT, EPA established a 1-day health advisory of 0.4 milligrams per liter (mg/L) and a 10-day health advisory of 0.04 mg/L in drinking water for a 10-kg child.
  - The drinking water equivalent levels for 2,4- and 2,6-DNT are 0.1 mg/L and 0.04 mg/L.
- For 2,6-DNT, EPA has calculated a residential soil screening level (SSL) of 3.3 x 10^{-1} mg/kg and an industrial SSL of 1.2 mg/kg. The soil-to-groundwater risk-based SSL is 3.2 x 10^{-4} mg/kg (EPA 2016b).

Are there any federal and state guidelines and health standards for DNT? (continued)

- For the mixture of 2,4- and 2,6-DNT, EPA has also calculated a residential SSL of 8.0 x 10^{-1} mg/kg and an industrial SSL of 3.4 mg/kg. The soil-to-groundwater risk-based SSL is 1.5 x 10^{-4} mg/kg (EPA 2016b).
- For 2,4-DNT, EPA has calculated a residential air screening level of3.2 x 10^{-2} micrograms per cubic meter (µg/m^3) and an industrial airscreening level of 1.4 x 10^{-1} µg/m^3. EPA has not established an ambient air screening level for 2,6DNT or the mixture of 2,4- and 2,6-DNT (EPA 2016b).
- For tap water, EPA has calculated screening levels of 2.4 x 10^{-1} µg/L for 2,4-DNT, 4.9 x 10^{-2} µg/L for 2,6-DNT, and 1.1 x 10^{-1} µg/L for 2,4- and 2,6-DNT mixture (EPA 2016b).
- In 2008, the EPA made a determination not to regulate either isomer with a national primary drinking water regulation based on the infrequent occurrence of the isomers at levels of concern in public water supply systems (EPA OGWDW 2008).
- 2,4- and 2,6-DNT are designated as hazardous substances under Section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act. Any discharge of 2,4-DNT over a threshold level of 10 pounds and 2,6-DNT over 100 pounds into navigable waters is subject to reporting requirements (EPA 2011).
- 2,4-DNT is a listed substance under the Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic Leaching Procedure (TCLP) organics list. If soils or wastes containing 2,4-DNT produce leachate with concentrations equal to or greater than the TCLP threshold (0.13 mg/L) for 2,4-DNT, they are classified as RCRA characteristic hazard waste and would require treatment (EPA 2006).
- Multiple states have adopted screening values or cleanup goals for 2,4-DNT, 2,6-DNT and/or the mixture of 2,4- and 2,6-DNT in soil ranging from 0.03 to 156 mg/kg for residential areas and 1.5 to 2,040 mg/kg for industrial areas.
- Various states have established drinking water or groundwater standards for 2,4-DNT, 2,6-DNT and/or the mixture of 2,4- and 2,6-DNT, including the following:

State	Guideline (µg/L)			Source
	2,4-DNT	2,6-DNT	Mixture	
Colorado	0.11	--	--	CDPHE 2016
Indiana	2.4	0.49	1.1	IDEM 2016
Maine	1	0.5	--	MDEP 2016
Maryland	7.3	3.7	--	MDE 2008
Michigan	7.7	--	--	Michigan DEQ 2013
Mississippi	73	36.5	0.0985	MDEQ 2002
Missouri	0.04	--	--	Missouri DNR 2014
Nebraska	0.22	9.1	0.099	NDEQ 2012
New Hampshire	10	--	--	NHDES 2015
New Mexico	2.17	36.5	0.988	NMED 2012
New York	5	5	--	NYDEC 2016
Ohio	2	0.42	0.92	Ohio EPA 2016
Oregon	--	0.049	--	Oregon DEQ 2015
Pennsylvania	2.4	0.49	--	PADEP 2016
Texas	0.0013	0.0013	--	TCEQ 2016
Virginia	2.4	0.48	--	VDEQ 2014
West Virginia	0.22	16	0.099	WVDEP 2014
Wyoming	66.7	33.3	--	WDEQ 2016

What detection and site characterization methods are available for DNT?

- Common analytical methods for DNT isomers rely on gas chromatography (GC) and high-performance liquid chromatography (HPLC) (ATSDR 2016; EPA 2008).
- GC is usually used in combination with various detectors including flame ionization detector, electron capture detector (ECD), Hall electrolytic conductivity detector, thermionic specific detector, fourier transform infrared, thermal energy analyzer or mass spectrometry (MS) (ATSDR 2016).
- Capillary GC columns with ECD have been developed to detect 2,4-DNT in both air and surface particulate samples (ATSDR 2016).
- Surface-enhanced raman spectroscopy was shown to detect 2,4-DNT vapor at a concentration level of 5 parts per billion (ppb) or less in air (ATSDR 2016; Sylvia and others 2000).
- Cross-reactive optical microsensors can detect 2,4-DNT in water vapor at a level of 23 ppb in clean, dry air (ATSDR 2016; Albert and Walt 2000).

What detection and site characterization methods are available for DNT? (continued)

- A continuous countercurrent liquid-liquid extraction method is capable of extracting 2,4- and 2,6-DNT from surface water samples (ATSDR 2016; Deroux and others 1996).
- Reversed-phase, HPLC enables the direct analysis of aqueous samples to identify DNT in wastewater. The estimated detection limit for 2,4-DNT is 10 µg/L (Jenkins and others 1986).
- Negative-ion chemical ionization is a sensitive and selective technique that has been used to identify trace amounts of nitroaromatic compounds in complex aqueous mixtures (ATSDR 2016; Feltes and others 1990).
- Pressurized fluid extraction and gas and liquid chromatography-MS can also be used to detect 2,4-DNT in soil (ATSDR 2016; Campbell and others 2003).
- In soils, a sonic extraction-liquid chromatographic method has been used to detect 2,4-DNT (ATSDR 2016; Griest and others 1993).
- EPA SW-846 Method 8330, HPLC using a dual wavelength ultraviolet (UV) detector, has been used for the detection of ppb levels of certain explosive and propellant residues, such as 2,4- and 2,6-DNT, in water, soil or sediment (EPA 2007b).
- EPA SW-846 Method 8095 uses capillary-column GC with an ECD to analyze for explosives, such as 2,4- and 2,6-DNT, in water and soil (EPA 2007a).
- EPA Method 529 uses solid phase extraction and capillary column GC and MS for the detection of 2,4- and 2,6-DNT in drinking water (EPA 2002).
- There are currently no EPA-approved analytical methods for the other four DNT isomers (2,3-DNT, 2,5-DNT, 3,4-DNT, and 3,5-DNT).

What technologies are being used to treat DNT?

- Treatment technologies include adsorption, chlorination, ozonation, and ultraviolet radiation (EPA 2008).
- Remediation technologies for DNT-contaminated soil and groundwater sites typically involve the use of separation processes, advanced oxidation processes, chemical reduction, bioremediation and phytoremediation (Rodgers and Bunce 2001).
- Adsorption on a solid phase, such as granular adsorbent, is the basic method to collect DNT from the atmosphere. This treatment is followed by removal with solvents such as chloroform (ATSDR 2016).
- Munitions wastewater containing DNT is commonly treated by activated carbon adsorption followed by incineration of the spent carbon (Chen and others 2011).
- As a result of its high efficiency and ease of operation, electrochemical oxidation has been applied successfully to treat DNT-contaminated wastewater (Chen and others 2011).
- Nanotechnology has emerged as a potential technology for the reductive chemical degradation of DNT in soil and groundwater. Studies have shown that lactate-modification of nanoscale iron particles (NIPs) can enhance the transport of NIPs and chemical degradation of 2,4-DNT in soil (Darko-Kagya and others 2010; Reddy and others 2011).
- Batch experiments demonstrated that in situ chemical oxidation using iron sulfide activated persulfate was able to degrade 2,4-DNT completely in water (Oh and others 2011).
- 2,4-DNT is more easily degraded than 2,6-DNT by bioremediation in soil and groundwater and sequential treatment systems may be needed to treat soil or water containing both isomers (Nishino and Spain 2001).
- Recent studies have achieved a 2,4-DNT removal efficiency above 99 percent in wastewater using a sequential anaerobic/aerobic biodegradation treatment method (Kuşçu and Sponza 2011; Wang and others 2011).
- Study results suggested that bioremediation and natural attenuation of DNT-contaminated groundwater may be an effective treatment option (Han and others 2011).
- Conventional methods to treat DNT in soils are incineration or landfilling, immobilization, thermal removal, bioremediation and solvent extraction (Darko-Kagya and others 2010).
- A protocol document for the application of alkaline hydrolysis to treat DNT and other explosives in soil ("Management of Munitions Constituents in Soil using Alkaline Hydrolysis") has been developed by the U.S. Army Corps of Engineers, Engineer Research and Development Center (ERDC) in Vicksburg, Mississippi (USACE 2011).

Where can I find more information about DNT?

- ATSDR. 2013 "Minimal Risk Levels (MRL)" List. www.atsdr.cdc.gov/mrls/index.asp
- ATSDR. 2016. "Toxicological Profile for Dinitrotoluenes." www.atsdr.cdc.gov/toxprofiles/tp109.pdf
- Albert, K.J., and D.R. Walt. 2000. "High-Speed Fluorescence Detection of Explosives-Like Vapors." Analytical Chemistry. Volume 72 (9). Pages 1947 to 1955.
- Bradley, P.M., Chapelle, F.H., Landmeyer, J.E., and J.G. Schumacher. 1994. "Microbial Transformation of Nitroaromatics in Surface Soils and Aquifer Materials." Applied and Environmental Microbiology. Volume 60 (2). Pages 2170 to 2175.
- Campbell, S., Ogoshi, R., Uehara, G., and Q.X. Li. 2003. "Trace Analysis of Explosives in Soil: Pressurized Fluid Extraction and Gas and Liquid Chromatography-Mass Spectrometry." Journal of Chromatographic Science. Volume 41 (6). Pages 284 to 288.
- Chen, Y., Shi, W., Xue, H., Han, W., Sun, X., Li, J., and L. Wang. 2011. "Enhanced Electrochemical Degradation of Dinitrotoluene Wastewater by Sn-Sb-Ag-Modified Ceramic Particulates." Electrochimica Acta. Volume 58. Pages 383 to 388.
- Clausen, J.L., Scott, C., and I. Osgerby. 2011. "Fate of Nitroglycerin and Dinitrotoluene in Soil at Small Arms Training Ranges." Soil and Sediment Contamination. Volume 20. Pages 649 to 671.
- Colorado Department of Public Health and Environment (CDPHE). 2016. "The Basic Standards for Ground Water." 5 CCR 1002-41. www.colorado.gov/pacific/sites/default/files/41_2016%2806%29hdr.pdf
- Darko-Kagya, K., Khodadoust, A.P., and K.R. Reddy. 2010. "Reactivity of Lactate-Modified Nanoscale Iron Particles with 2,4-Dinitrotoluene in Soils". Journal of Hazardous Materials. Volume 182. Pages 177 to 183.
- Deroux, J.M., Gonzalez, C., Le Cloirec, P. and G. Kovacsik. 1996. "Analysis of Extractable Organic Compounds in Water by Gas Chromatography Mass Spectrometry: Applications to Surface Water." Talanta. Volume 43 (3). Pages 365 to 380.
- Feltes, J., Levsen, K., Volmer, D, and M. Spiekermann. 1990. "Gas Chromatographic and Mass Spectrometric Determination of Nitroaromatics in Water." Journal of Chromatography. Volume 518 (1). Pages 21 to 40.
- Griest, W.H., Stewart, A.J., Tyndall, R.L., Caton, J.E., Ho, C.H., Ironside, K.S., Caldwell, W.M. and E. Tan. 1993. "Chemical and Toxicological Testing of Composted Explosives-Contaminated Soil." Environmental Toxicology and Chemistry. Volume 12 (6). Pages 1105 to 1116.
- Han, S., Mukherji, S.T., Rice, A., and J.B. Hughes. 2011. "Determination of 2,4- and 2,6-Dinitrotoluene Biodegradation Limits." Chemosphere. Volume 85. Pages 848 to 853.
- Hartley, W.R., Roberts, W.C. and B.J. Commons (eds). 1994. Drinking Water Health Advisory: Munitions II. Professional Administrative Services, Office of Drinking Water Health, U.S. Environmental Protection Agency.
- Hazardous Substances Data Bank (HSDB). 2013. "Dinitrotoluene," "2,4- Dinitrotoluene," and "2,6- Dinitrotoluene." https://toxnet.nlm.nih.gov
- Indiana Department of Environmental Management (IDEM). 2016. "Remediation Closure Guide." Table A-6: IDEM OLQ 2016 Screening Levels. www.in.gov/idem/landquality/files/risc_screening_table_2016.pdf
- Jenkins, T.G., Leggett, D.C., Grant, C.L., and C.F. Bauer. 1986. "Reversed-Phase High Performance Liquid Chromatographic Determination of Nitroorganics in Munitions Wastewater." Analytical Chemistry. Volume 58 (1). Pages 170 to 175.
- Kuşçu, O.S., and D.T. Sponza. 2011. "Application of Box-Wilson Experimental Design Method for 2,4-Dinitrotoluene Treatment in a Sequential Anaerobic Migrating Blanket Reactor (AMBR)/Aerobic Completely Stirred Tank Reactor (CSTR) System." Journal of Hazardous Materials. Volume 187. Pages 222 to 234.
- Lent, E.M., Crouse, L., Quinn Jr., M.J., and S.M Wallace. 2012a. "Assessment of the In Vivo Genotoxicity of Isomers of Dinitrotoluene Using the Alkaline Comet and Peripheral Blood Micronucleus Assays." Mutation Research. Volume 742. Pages 54 to 60.
- Lent, E.M., Crouse, L., Quinn Jr., M.J., and S.M Wallace. 2012b. "Comparison of the Repeated Dose Toxicity of Isomers of Dinitrotoluene." International Journal of Toxicology. Volume 31 (2). Pages 143 to 157.

Where can I find more information about DNT? (continued)

- Maine Department of Environmental Protection (MDEP). 2016. "Maine Remedial Action Guidelines (RAGs) for Sites Contaminated with Hazardous Substances." www.maine.gov/dep/spills/publications/guidance/rags/ME-RAGS-Revised-Final_020516.pdf
- Maryland Department of the Environment (MDE) 2008. "Cleanup Standards for Soil and Groundwater." http://www.mde.maryland.gov/assets/document/final%20update%20no%202.1%20dated%205-20-08(1).pdf
- Michigan Department of Environmental Quality (DEQ). 2013. Groundwater: Residential and Non-Residential. http://www.michigan.gov/documents/deq/deq-rrd-Rules-Table1GroundwaterResidentialandNon_447070_7.pdf
- Mississippi Department of Environmental Quality (MDEQ). 2002. Risk Evaluation Procedures for Voluntary Cleanup and Development of Brownfield Sites, Tier 1 TRG Table. http://www.deq.state.ms.us/MDEQ.nsf/pdf/GARD_brownfieldrisk/$File/Proced.pdf?OpenElement
- Missouri Department of Natural Resources (DNR). 2014. Rules of Department of Natural Resources, Chapter 7 Water Quality. http://s1.sos.mo.gov/cmsimages/adrules/csr/current/10csr/10c20-7a.pdf
- Naval Facilities Engineering Command (NAVFAC). 2003. "Assessment of Environmental Effects of Ordnance Compounds and their Transformation Products in Coastal Ecosystems." Technical Report. TR-2234-ENV. www.dtic.mil/dtic/tr/fulltext/u2/a424122.pdf
- Nebraska Department of Environmental Quality (NDEQ). 2012. "VCP Remediation Goals." deq.ne.gov/Publica.nsf/xsp/.ibmmodres/domino/OpenAttachment/Publica.nsf/D243C2B56E34EA8486256F2700698997/Body/ATTIY3JX.pdf
- New Hampshire Department of Environmental Services (NHDES). 2015. Code of Administrative Rules, Part 603. "Ambient Groundwater Quality Standards." http://des.nh.gov/organization/commissioner/legal/rules/documents/env-or600.pdf
- New Mexico Environment Department (NMED). 2012. "Risk Assessment Guidance for Site Investigations and Remediation." www.env.nm.gov/HWB/documents/NMED_RA_Guidance_for_SI_and_Remediation_Feb_2012_.pdf
- New York Department of Environmental Conservation (NYDEC). 2016. Part 703. Surface water and groundwater quality standards and groundwater effluent limitation. https://govt.westlaw.com/nycrr/Document/I4ed90418cd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)&bhcp=1
- Nishino, S.F., and J.C. Spain. 2001. "Technology Status Review: Bioremediation of Dinitrotoluene (DNT)." Strategic Environmental Research and Development Program.
- Occupational Safety and Health Administration (OSHA). 2013. "Dinitrotoluene" Chemical Sampling Information. www.osha.gov/dts/chemicalsampling/data/CH_237000.html
- Oh, S., Kang, S., Kim, D., and P.C. Chiu. 2011. "Degradation of 2,4-Dinitrotoluene by Persulfate Activated with Iron Sulfides." Chemical Engineering Journal. Volume 172. Pages 641 to 646.
- Ohio Environmental Protection Agency (EPA). 2016. Chemical Information Database and Applicable Regulatory Standards. http://www.epa.state.oh.us/derr/rules/guidance.aspx#119153115-risk-assessment
- Oregon Department of Environmental Quality (DEQ). 2015. Risk-based Concentrations. http://www.deq.state.or.us/lq/pubs/docs/RBDMTable.pdf
- Pennsylvania Department of Environmental Protection (PADEP). 2016. "Table 1: Medium Specific Concentrations (MSCs) for Organic Regulated Substances in Groundwater." http://www.dep.pa.gov/Business/Land/LandRecycling/Standards-Guidance-Procedures/Pages/Statewide-Health-Standards.aspx
- Reddy, K.R., Darko-Kagya, K., and C. Cameselle. 2011. "Electrokinetic-Enhanced Transport of Lactate-Modified Nanoscale Iron Particles for Degradation of Dinitrotoluene in Clayey Soils." Separation and Purification Technology. Volume 79. Pages 230 to 237.

Where can I find more information about DNT? (continued)

- Rocheleau, S., Kuperman, R.G., Simini, M., Hawari, J., Checkai, R.T., Thiboutot, S., Ampleman, G., and G.I. Sunahara. 2010. "Toxicity of 2,4-Dinitrotoluene to Terrestrial Plants in Natural Soils." The Science of the Total Environment. Volume 408. Pages 3192 to 3199.
- Rodgers, D., and N.J. Bunce. 2001. "Treatment Methods for the Remediation of Nitroaromatic Explosives." Water Research. 35. Pages 2101 to 2111.
- Singh, N., Berns, A.E., Hennecke, D., Hoerner, J., Koerdel, W., and A. Schaeffer. 2010. "Effect of Soil Organic Matter Chemistry on Sorption of Trinitrotoluene and 2,4-Dinitrotoluene." Journal of Hazardous Materials. Volume 173. Pages 343 to 348.
- Sylvia, J.M., Janni, J.A., Klein, J.D., and K.M. Spencer. 2000. "Surface-Enhanced Raman Detection of 2,4-Dinitrotoluene Impurity Vapor as a Marker to Locate Landmines." Analytical Chemistry. Volume 72 (23). Pages 5834 to 5840.
- Texas Commission on Environmental Quality (TCEQ). 2016. "TRRP Protective Concentration Levels." www.tceq.texas.gov/remediation/trrp/trrppcls.html
- USACE. 2011. "Management of Munitions Constituents in Soil Using Alkaline Hydrolysis." ERDC/EL TR-11-16.
- EPA. 2002. Method 529. "Determination of Explosives and Related Compounds in Drinking Water by Solid Phase Extraction and Capillary Column Gas Chromatography/Mass Spectrometry (GC/MS)." Revision 1.0. EPA/600/R-05/052.
- EPA. 2006. "Characteristics of Hazardous Waste - Toxicity Characteristic." Code of Federal Regulations (CFR). CFR Section 261.24.
- EPA. 2007a. SW-846. Method 8095. "Explosives by Gas Chromatography." https://www.epa.gov/hw-sw846/sw-846-test-method-8095-explosives-gas-chromatography
- EPA. 2007b. SW-846. Method 8330A. "Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)." Revision 1. https://www.epa.gov/sites/production/files/2015-07/documents/epa-8330b.pdf
- EPA. 2008. "Drinking Water Health Advisory for 2,4-Dinitrotoluene and 2,6-Dinitrotoluene." EPA 822-R-08-010. https://www.epa.gov/sites/production/files/2014-09/documents/drinking_water_health_advisory_for_24_and_26_dinitrotoluene.pdf
- EPA. 2011. Reportable Quantities of Hazardous Substances designated pursuant to Section 311 of the Clean Water Act. Code of Federal Regulations 40 CFR 302.4.
- EPA. 2012a. "2012 Edition of the Drinking Water Standards and Health Advisories." EPA 822-S-12-001. https://www.epa.gov/sites/production/files/2015-09/documents/dwstandards2012.pdf
- EPA. 2013a. "Provisional Peer-Reviewed Toxicity Values for 2,6-Dinitrotoluene." Superfund Health Risk Technical Support Center.
- EPA. 2013b. "Provisional Peer-Reviewed Toxicity Values for Technical Grade Dinitrotoluene." Superfund Health Risk Technical Support Center.
- EPA 2016a. Search Superfund Site Information. https://cumulis.epa.gov/supercpad/cursites/srchsites.cfm
- EPA. 2016b. Regional Screening Level (RSL) Summary Table. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016
- EPA. Integrated Risk Information System (IRIS). 1990. "2,4-/2,6-Dinitrotoluene mixture." www.epa.gov/iris/subst/0397.htm
- EPA. IRIS. 1992. "2,4-Dinitrotoluene." www.epa.gov/iris/subst/0524.htm
- EPA. Office of Ground Water and Drinking Water (OGWDW). 2008. "Regulatory Determinations Support Document from the Second Drinking Water Contaminant Candidate List (CCL 2). Chapter 7: 2,4- and 2,6-Dinitrotoluene." EPA 815-R-08-012. https://www.epa.gov/sites/production/files/2014-09/documents/report_ccl2-reg2_supportdocument_full.pdf
- Virginia Department of Environmental Quality (VDEQ). 2014. "VRP Table 2.6: Selection of Contaminants of Concern." www.deq.state.va.us/Portals/0/DEQ/Land/RemediationPrograms/VRPRisk/Screen/vrp26.xlsx
- Wang, Z.Y., Ye, Z.F., and M.H. Zhang. 2011. "Bioremediation of 2,4-dinitrotoluene (2,4-DNT) in Immobilized Micro-Organism Biological Filter. Journal of Applied Microbiology." Volume 110. Pages 1476 to 1484.

Where can I find more information about DNT? (continued)

- West Virginia Department of Environmental Protection (WVDEP). 2014. "VRP Table §60-3B, De Minimis Table." www.dep.wv.gov/dlr/oer/voluntarymain/Pages/default.aspx
- Wyoming Department of Environmental Quality (WDEQ). 2016. "VRP Soil and Groundwater Cleanup Level Tables." deq.wyoming.gov/media/attachments/Solid%20%26%20Hazardous%20Waste/Voluntary%20Remediation%20Program/Fact%20Sheets/SHWD_Vrp_Factsheet12D%20Soil%20And%20Groundwater%20Cleanup%20Level%20Tables2016.xlsx

Contact Information

If you have any questions or comments on this fact sheet, please contact Mary Cooke, FFRRO, by email at cooke.maryt@epa.gov.